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ABSTRACT

Information graphics or diagrams are two-dimensional maps of relationships that present information. Creators and interpreters of diagrams need to know what makes some diagrams more effective in communicating information. This paper suggests a theoretical framework for diagram classification to make this possible. This framework consists of two related continua along the x-axis: categories of information structure, ranging from equidistant interval through ordinal to nominal, appear in the upper, horizontal coordinate; and categories of layout and design, ranging from technical through formal to informal, appear along the lower, horizontal coordinate. The definition of equidistant interval/technical array~ provides a clear division from the rest of the horizontal continuum. The definitions of ordinal and nominal categories also yield an explicit break. The formal/informal boundary is not as clearly defined. As a result, the farther a diagram moves to the right along the framework, the more intuitive the decisions become regarding diagram features. From this framework, research questions into graphic literacy could begin by focusing upon the effectiveness of various diagrams based on the type of communication used to convey information. (Contains 14 references.) (JLB)

A Theoretical Framework for Diagrams and Information Graphics in Research and Education

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Pervasive Graphic Information

In a time labeled the information age, graphic information abounds. New technologies promote easier creation of graphic information, old formats emerge with new names, and designers explore fresh approaches to presenting information visually. Whether we call them information graphics or diagrams, two-dimensional maps of relationships present information in classrooms, board rooms, promotional displays, news reports, books and on TV screens, computer monitors and billboards.

Good diagrams promote understanding so well that their design elements are virtually transparent. As long as layouts contribute to the communicative power of diagrams, we take them for granted; diagram "readers" seldom mention the diagram itself unless its format or design elements prove to be confusing.

Even dictionaries make broad assumptions about the effectiveness of diagrams. One typical definition reads:

> 1. A plan, sketch, drawing or outline, not necessarily representational, designed to demonstrate or explain something or clarify the relationship existing between the parts of a whole.... 3. A chart or graph. (The *American Heritage Dictionary of the English Language*. 1970. p 363)

Most dictionaries surveyed present definitions asserting that diagrams clarify relationships and promote understanding. Objectively, we realize that clarification and understanding only occur in the mind of the diagram "reader" and not in the diagram. But diagram users, both creators and interpreters, need to know what makes some diagrams more effective in fostering clear communication. This paper suggests first a theoretical framework for diagram classification. Then, it proposes areas of investigation that should lead to more effective communication in some categories of diagrams.

Where Information Structure Meets Graphic Design

The link between information structure and diagram format is the vital core of a diagram's reason for being. A classification system for diagrams should consider both the structure of the information to be diagrammed and diagrammatic format.

In *How to Create High-impact Business Presentations*, Kupsh and Graves (1992) divide diagrams into two categories: "place" and "process." By acknowledging information structure, the authors move in a positive direction. The "place" category covers such divergent schema as maps, floor plans and organizational charts. The "process" category includes information like flow diagrams, and time lines. In actual practice, the place/process designations yield broad, sometimes overlapping, categories—is an organizational chart place or process? Which category includes graphs that present information plotted along two or more coordinates?

Kupsh and Graves treat diagrams addressing numerical orders, juxtaposed and plotted in a separate chapter on graphs. Yet, by definition, they are diagrams.

A complete classification system for diagrams must accommodate the full range of schematics; place, process and static numerical plots. In his introduction to *Diagraphics*, Nigel Holmes (Japan Creators' Association, 1986) addresses the role of numbers in graphs:

> "Unexplained numbers are not information. We mistakenly refer to the 'Information Explosion' in the world today. There is no information explosion—it's a numbers explosion, and it falls to designers to turn the numbers into useful information." (Wildbur, 1989, p 57)

three-part continuum running from technical through formal to informal for use in categorizing diagram formats and design devices. In Figure 1, the two continua run parallel—categories of information structure appear along the upper horizontal coordinate and categories of layout and design along the lower, horizontal coordinate. The left-most pair of categories—equidistant interval and technical_carry definitions that yield a neatly defined border between them and the remaining categories to the right. The definitions of ordinal and nominal also yield a clear demarcation. However, the boundary between formal and informal is more of a continuum. Hence a breakdown in neat, enclosed regions and the introduction of a less explicit transition. Vertical placement represents the ex' ...t

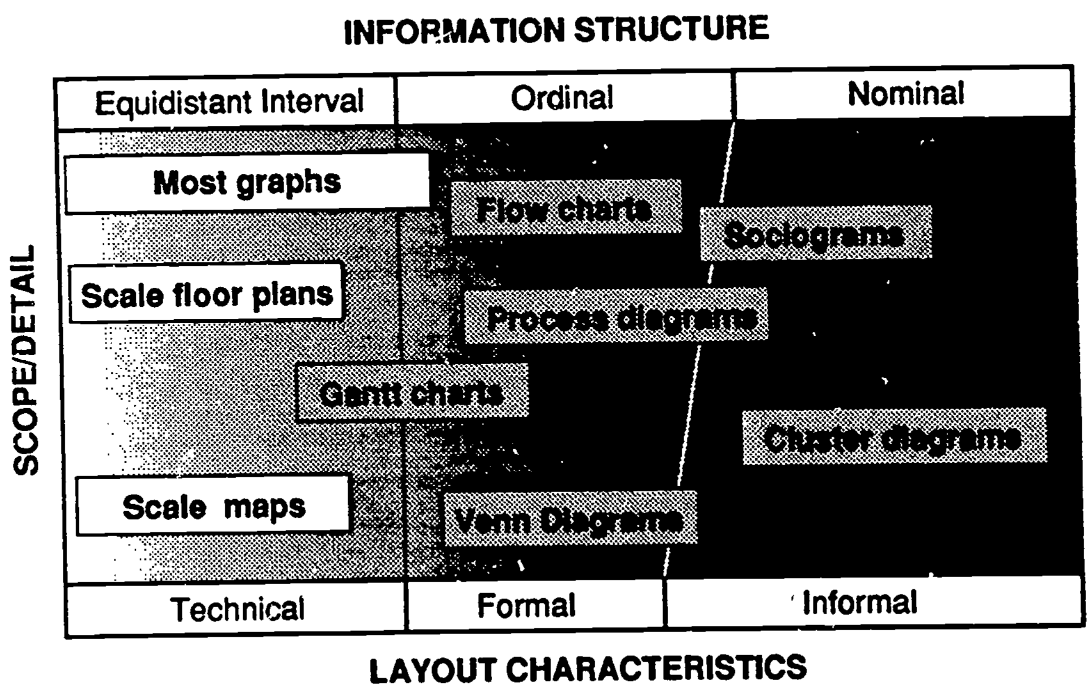

Figure 1 – A schema presenting two, correlated continua along the x-axis. The field encompasses all information graphics.

A search of the literature for organizational categories for information structure and diagram layout yields two continua that may be adapted to fit the need. From statistical literature comes a continuum of information structure ranging from equidistant interval through ordinal to nominal. From cultural anthropology (Hall, 1959) comes another

to which all the details within a diagrammatic array conform to its place on the horizontal continua—diagrams with the most homogeneous treatment of data appear toward the top of the field; those with mixed approaches to information presentation fit into the matrix farther down the image.

A brief clarification of how the categories of terms work together follows.

Equidistant Interval/technical Diagrams

Equidistant interval data, information that conforms to diagrammatic arrays, must have a minimum of two coordinates (x, y and sometimes z); these diagrams must conform to constraints of an interval scale (Figure 2). The literature defining accepted procedures is easily identified; violations of the published rules constitute a "wrong" diagram. This is a fundamental trait of Edward Hall's definition of technical norms. That is, we can readily

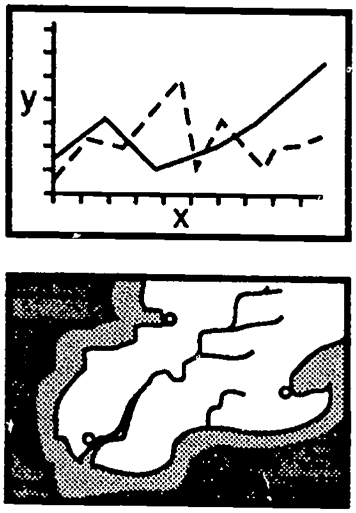

Figure 2 – Samples of equidistant interval/technical diagrams.

identify rules for plotting and presenting such information as graphs, floor plans and maps. Peter Wildbur (1989, p. 46) cites such a rule when presenting a 19th century graph by William Playfair that omits 20 years of relevant data. Today, he asserts, we would "hardly accept" the omission. William was not playing fair!

Ordinal/formal Diagrams

Ordinal/formal diagrams display information that has sequential structure along at least one coordinate. Ordinal in nature, the scale of a time line or flow chart along one continuum may vary from segment to segment within the diagram (Figure 3).

The rules governing design of ordinal/formal diagrams are less explicit than those governing equidistant interval graphs, maps

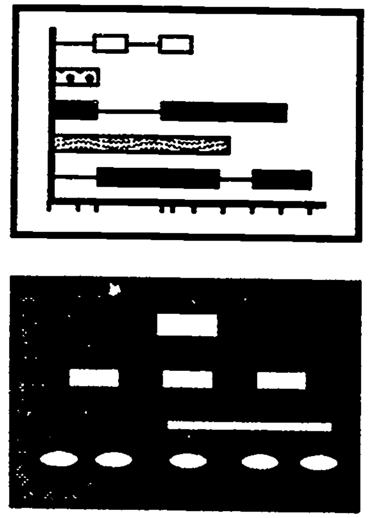

Figure 3 – Samples of ordinal/formal diagrams.

and drawings. Violations of the rules for ordinal/formal diagrams only occur when a node or entity is placed out of proper sequence in relation to other nodes or when linkages draw untrue connections between nodes. When readers of ordinal/formal diagrams locate an error in diagram construction, they are able explain how to correct the error. The "formal" designation connotes knowledge that we learn in organized training situations—at home, at school, in our work place; knowledge for which we can state structural and formatting guidelines. Hierarchical charts, flow diagrams and process schemata fall into this category. Sequential information usually translates into an overall directionality in diagram layout. Diagrammers can agree upon a starting point for an ordinal/formal diagram.

Nominal/informal Diagrams

As maps of relationships, nominal/informal diagrams feature multiple directions and reveal connections in the form of proximity, overlapping and networks or webs. Successful placement of nodes and connectors encodes intensity of relationship and relative importance. Temporal, sequential factors may be present but they apply only to small

segments of the network rather than to an overall, coordinated flow of information (Figure 4). Nominal/informal diagrams may be "readable" starting at any of several points in the network. Sociograms, cluster diagrams and brainstorming networks typically represent nominal information.

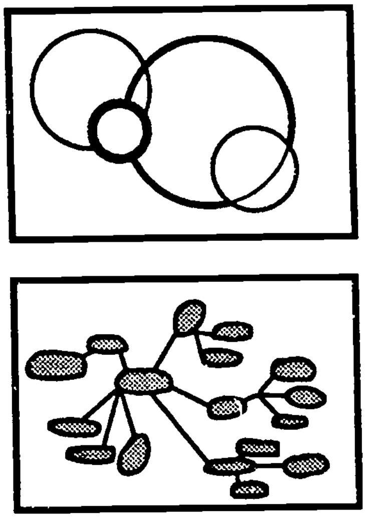

Figure 4 – Samples of nominal/informal diagrams.

The rules for constructing such arrays depend upon design devices like grouping, chunking, superimposition and partitioning. Users of nominal/informal diagrams recognize incorrect diagram features easily but may find difficulty agreeing on how to correct the problem; the rules for nominal/informal diagrams appear to be held intuitively. When the diagram is well designed, the message comes across clearly; both creators and users take the format and design devices for granted. By contrast, weak layouts obscure the information structure leaving interpreters puzzled. Reactions may be self-critical, "I seldom understand diagrams very well."

Defining Boundaries Between Categories

The definition of equidistant interval/technical arrays provides a neat, clean division from the rest of the horizontal continuum. Definitions of ordinal and nominal categories of information also yield an explicit break between the two. The formal/informal boundary is, however, clouded (Figure 5).

Categorization of diagram types from equidistant interval/technical through ordinal/formal to nominal/informal offers a broad perspective within which research and discussion of many important details of diagrammatic communication can take place. The many information types and diagram formats in current use have contributed to imprecise speculation and inappropriate comparisons; understanding the difference between "apples and oranges" and "apples and doorknobs" would avoid some serious errors. With vigorous discussion and some modification, the framework depicted in Figure 1 may evolve into a common ground for more precise investigation of diagrams—a powerful communication device.

Diagrams as Models of Thought

For the moment, consider diagrams that belong in the right half or two-thirds of the proposed schema. The farther the

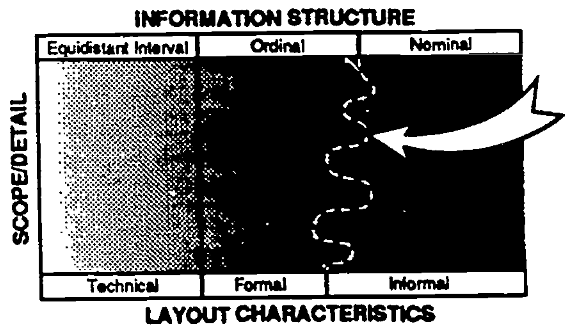

Figure 5 – The indeterminate edge between formal and informal diagram categories.

diagrammer/interpreter moves to the right along Figure 1's continuum, the more intuitive become the decisions regarding meaningful size and placement of nodes. The same is true for the rendering details and graphic style of connectors. (NOTE: Even in diagrams placed at the far right edge of the continuum, relationships indicated by connectors are either correct or incorrect. This is a fundamental factor separating diagrams, as statements of relationships, from art.)

The greater the intuitive contribution, the harder it is to make logical, verbal explanations for diagram layout decisions. At the extreme right side of the continuum, cluster

diagrams created by brainstormers may commence anywhere on the page and sprawl lopsidedly in any direction that intuition directs. But, evidence suggests that there are, indeed, commonly held rules guiding these intuitive decisions (Hardin, 1981). Advocacy for creating such diagrams as aids to learning, writing and organizing abounds (Buzan, 1974; Hardin, 1983; Rico, 1983).

The visual or graphic literacy surrounding diagrams deserves further investigation. Is the value of creating ordinal and nominal, free-layout diagrams limited only to the diagrammers themselves? Do the rules for layout change when diagrams present information to viewers who did not participate in the creation of the array? What layout and design devices make free-layout diagrams most meaningful to diagram interpreters?

Designers not only know how to incorporate diagrammatic layout and design devices into powerful diagrams, they trust in a visual literacy for diagrams among viewers.

> One of the spin-offs from the mass media is the increased exposure of the reader and viewer to a variety of sophisticated graphic treatments such as pictograms and diagrammatic techniques which means that the designer can assume a familiarity with certain forms and treatments, — a form of graphic literacy, which was not the case even a few years ago. (Wildbur, P., 1989, p 7)

As long as Wildbur's "certain forms and treatments" remain the province of designers, diagrams composed by non-designers will express only their untrained intuition.

Two remedies seem obvious. By investigating diagrammatic syntax, we can better prepare ourselves and those who come after us to communicate information through diagrams. Also, we should encourage non-designers to produce diagrams frequently on the theory that practice will increase skill. We do not expect language arts students to become better writers without practicing and critiquing writing; we should promote increased diagram production and critiquing, too.

Writing across the curriculum is a great idea—math and science teachers should be teaching the importance of writing skill in their fields. But we expect the language arts teacher to have the special know-how to evoke the greatest writing skill from students. Who then shall we look to for the special expertise to teach diagramming skills? How will these teachers learn what diagramming skills to teach or how to teach them?

A circular dilemma emerges. Whether we learn from practicing designers or from more formal research, we must know more about diagram dynamics in order to improve diagrammatic instruction. With better instruction, knowledgeable diagrammers will be available to conduct investigations to learn how diagrams work!

Research questions could begin by focusing upon the effectiveness of various design devices in the context of communicating various types of information. The underlying hypothesis for such research is that design format and selected design devices inform and influence understanding of the diagram; that diagrammers can avoid dissonance between information structure and layout strategies if they know more about how these two elements of a diagram interact.

- What types of arrows are most effective for various types of information? ...technical label pointers, directional flow in organizational charts, descriptions of flow paths in process schema, or links in cluster diagrams?
- What devices best show linkages in selected information categories? ...proximity, framed boxes, linear alignment, lines, arrows?
- Does overall thrust of diagram flow communicate a certain type of information to viewers? What are the messages communicated by differing points of origin; flows from left to right, diagonal or top to bottom; twisting, bending or radial paths?
- How do changes in layout flow communicate information within a diagram?

Investigators should not have to look far for tools with which to conduct diagram research. While serious studies of diagram effectiveness remain outside of the main stream of research, some efforts exist (Hardin, 1983). The advent of computer programs for

creating diagrams should be one of the greatest aids to diagram research. Efforts to create such software date back to the earliest programming endeavors. It is hardly surprising that the first developments were in support of equidistant interval/technical diagrams. Gradually, software is emerging that ventures into the ordinal/formal and nominal/informal categories. Whatever the type of information supported by a computer-driven diagram generator, it's effectiveness will depend upon the versatility offered to diagrammers to choose from a broad range of diagram formats and design devices.

Arrow styles offer a good example of this problem. The choice of squared-off, symmetrical arrows as opposed to swooping, dynamic curved arrows ought to be related to the type of information the arrow serves. When rigid, blocky arrows are the only ones available to the diagram designer, they serve poorly in describing node connections involving speed, fluidity, uncertainty or intermittence. Yet, many diagrams employ the blocky, squared off arrows for poor reasons—the template only had one kind of arrow or the computer program only makes squared-off arrows.

Recent experience with *Inspiration,*™ a versatile software package designed for brainstorming, organizing and project/presentation management, suggests that it could become a vital tool for the conduct of diagram research.

Inspiration has already found enthusiastic support among educators. The company produces a special collection of diagrams and diagramming ideas contributed by teachers. This publication not only offers a broadly based array of lesson ideas but it exemplifies the basic premise of this paper—a better understanding of the visual literacy surrounding diagrams is needed to assure more powerful communication in the diagrammatic arena. *Inspiration's* adoption in the classroom endorses its suitability as a research tool; it is relatively easy to learn, offers an increasingly broad array of diagrammatic formats and design devices, and allows for several managerial controls that would enable researchers to adapt it to a research design.

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